UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Scope of Work: Utah Lake Sediment–Water Nutrient Interactions

1 Introduction

The Utah Department of Environmental Quality, Division of Water Quality (DWQ) is requesting grant proposals for technical support to conduct experiments to characterize the sediment-phosphorus chemistry of Utah Lake. Sediment-phosphorus chemistry of the lake was prioritized for 2019 by the Utah Lake Water Quality Study (ULWQS) Science Panel to determine the sediment-phosphorus equilibrium, release of nutrients from the sediment, sediment oxygen demand, and related sediment chemistry in the lake. The target completion date of the work is December 31, 2019.

Please submit a grant proposal including a cost proposal to Emily Canton at ercanton@utah.gov by 5:00 PM MST May 22, 2019. Proposals must be limited to 10 pages; this page limit does not include resumes and project case studies that may be included in an appendix.

2 Background

The Utah Division of Water Quality (DWQ) recently initiated Phase 2 of the Utah Lake Water Quality Study (ULWQS) to evaluate the effect of excess nutrients on the lake's recreational, aquatic life, and agricultural designated uses and to develop site-specific nitrogen and phosphorus water quality criteria to protect these uses. The ULWQS is guided by the Stakeholder Process (Attachment A) developed during Phase 1, which established a 16-member interest-based Steering Committee and a 10-member disciplinary-based Science Panel. The Steering Committee has charged the Science Panel with developing and answering key questions to characterize historic, current, and future nutrient conditions in Utah Lake (Attachment B). Responses to the key questions will be used by the Steering Committee to establish management goals for the lake and by the Science Panel to guide development of nutrient criteria to support those goals.

Additionally, the Science Panel must complete a significant number of tasks to achieve its purpose of guiding the development of nutrient criteria including:

- Guiding the approach for establishing nutrient criteria
- Recommending and guiding studies to fill data gaps needed to answer key questions

- Interpreting and integrating study results into the rationale for nutrient criteria
- Guiding development of an approach for characterizing uncertainty
- Recommending science-based nutrient criteria to the Steering Committee

Problem Statement

Understanding the cycling of nutrients within Utah Lake will help describe the current state of the lake with respect to nutrients and ecology, and sediments are an important component of the nutrient cycling within the lake. Available reports and initial information on sediment oxygen demand (SOD) and nutrient release from sediments in Utah Lake provide some insight into sediment phosphorus characteristics and fluxes, but stop short of converting bulk measurements into mobile or bioavailable fractions. Available reports also provide some insight into the relationship between calcite and phosphorus in the lake. High calcite concentrations observed in surface sediments and cores suggest that carbonate precipitation from the Utah Lake water column, and possibly associated turbidity, have been components of the Utah Lake system for millennia, but not all available sediment core data are consistent.

Existing Data and Information

Hogsett and Goel (2013) report lake sediment phosphorus speciation and mineralogy, as well as sediment and water column oxygen demand. Merrell (2015) reports phosphorus and iron content of lake sediments and near-lake soils, as well as a qualitative description of phosphorus fluxes from lake sediments under oxic and anoxic conditions. It is noted in the Utah Lake Literature Review (Attachment C) that the results of the two studies differ in terms of reported percentage of lake sediment phosphorus that is bound to calcium.

Randall (2017) quantified lake sediment phosphorus in 26 sediment samples, with phosphorus concentrations ranging from 306 to 1,894 ppm, and the highest being from Provo Bay. Results showed that approximately 25–50 percent of phosphorus is bound with calcium minerals. The study also included batch sorption experiments, which indicate that lake sediments have a capacity to adsorb 70–96 percent of water column phosphorus over the range of 1 to 10 mg/L phosphorus.

Abu-Hmeidan et al. (2018) carried out a lake-wide sediment sampling study that showed similar phosphorus concentrations in lake sediment to those in surrounding soils (average of 666 ppm, typical range of 600-800 ppm), suggesting the importance of geological phosphorus sources to lake sediments. Phosphorus hotspots were located near known anthropogenic nutrient sources (a feedlot and tributary outlets containing wastewater effluent), and areas of low phosphorus were associated with groundwater seeps. Simple lab experiments designed to show the potential mobility of phosphorus from sediments were suggestive but not conclusive. The overall conclusion that the eutrophic state of the lake was due to natural phosphorus rather than anthropogenic phosphorus was not consistent with some observed data of phosphorus hotspots, and bioavailability of phosphorus in sediments was not actually quantified; only bulk phosphorus was quantified, much of which may not be bioavailable.

Brimhall and Merritt (1981) describe a 520-cm sediment core from Utah Lake, along with surface sediment analyses from 140 stations. Direct age control (e.g., radioisotopes or pollen) was not reported for the sediment core, but estimation of sedimentation rates based on assignment of a subsurface seismic reflector as corresponding to the last Lake Bonneville deposits yielded linear sedimentation rates of 0.8 to 1.5 mm/yr. Peat/sand at 450-cm depth in the core was assigned to the altithermal period (very arid) about 5,000 years ago. Surface calcite concentrations ranged from 35–80 percent and were lowest in bays and along the east shore, but highest in the north central area of the lake. Down-core calcite ranged from 20 to 30 percent of the sediment, with the balance attributed to silica (quartz, diatoms) and clays. A 0.5-meter-thick nepheloid/fluid mud layer was typically observed at the sediment surface during sampling.

Study Objectives

The objective of this research is to address the following questions identified by the Science Panel as critical to understanding the current state of Utah Lake with respect to nutrients and ecology:

- What are current sediment equilibrium phosphorus concentrations (EPC) throughout the lake? (Science Panel charge 2.4.i, Attachment B).
- What is the role of anoxia in nutrient releases and sediment dynamics over a range of phosphorus concentrations?
- What is the role of pH in water column–sediment interactions and nutrient releases? How does the equilibrium phosphorus concentration change over a range of water column pH?
- What is the sediment oxygen demand of, and nutrient releases from, sediments in Utah Lake under current conditions? (Science Panel charge 2.4.ii, Attachment B).
- What is the role of calcite "scavenging" in the phosphorus cycle? (Science Panel charge 2.3.v, Attachment B). What is the role of sediment resuspension on nutrient releases or removal, primarily via calcite scavenging?

Expected Outcomes and Outputs

When this study is completed, the Science Panel will be able to answer the study objectives listed above.

Specific outputs are expected to include, but are not limited to, a sampling and analysis plan (SAP), the project dataset, and a technical report. All data collected for this project must be made available to the Science Panel per the deliverable dates schedule in Section 6 of this RFP.

3 Supporting Materials

A number of reports and documents were developed during the course of the ULWQS and previous study efforts on Utah Lake. These documents are provided as attachments for reference during response development. Additional ULWQS information including data, reports, meeting summaries, meeting recordings, and other related materials are available at utahlake.deq.utah.gov. A list and brief description of the relevant materials is included here:

Attachment A. Stakeholder Process https://documents.deq.utah.gov/water-quality/watershed-protection/utah-lake/DWQ-2017-004494.pdf. This document prescribes the structure, objectives, and duties of the Steering Committee, Science Panel, and other organizations with a role in the ULWQS. This process is directed by an independent professional facilitation team.

Attachment B. ULWQS Phase 2 Purpose and Initial Charge to Science Panel from Steering Committee. This document describes the Initial High Level Charge questions developed by the Steering Committee and an initial list of key questions designed to answer each high level charge https://documents.deq.utah.gov/water-quality/locations/utah-lake/DWQ-2019-001842.pdf.

Attachment C. Utah Lake Literature Review – This literature review was developed as a Phase 1 task and assessed the ability of existing literature and studies to answer the Initial High Level Charge questions presented in the ULWQS Phase 2 Initial Charge document. See select references in the Utah Lake Literature Review under *Topical Category 1: In-Lake Water Quality Conditions* for a list and findings of references relevant to historical conditions in Utah Lake. https://documents.deq.utah.gov/water-quality/locations/utah-lake/DWQ-2019-001842.pdf

Attachment D. Quality Assurance Program Plan for Environmental Data Operations, Final Plan, Revision No. 1.0, Effective September 5, 2014. https://deq.utah.gov/water-quality/quality-assurance-and-quality-control-program-monitoring-water-quality

References:

Abu-Hmeidan, H.Y., Williams, G.P. and Miller, A.W., 2018. Characterizing Total Phosphorus in Current and Geologic Utah Lake Sediments: Implications for Water Quality Management Issues. *Hydrology* 5(1): 8.

Brimhall, W. H. and Merritt, L. B. 1981. Geology of Utah Lake: implications for resource management. *Great Basin Naturalist Memoirs*: Vol. 5, Article 3.

Hogsett, M., and R. Goel, 2013. *Determination of nutrient fluxes and sediment oxygen demand at selected locations in Utah Lake*. Civil & Environmental Engineering, University of Utah, Prepared for: Utah Division of Environmental Quality.

Merrell, P. D., 2015. *Utah Lake Sediment Phosphorus Analysis*. M. S. thesis. Brigham Young University. Department of Civil and Environmental Engineering.

Randall, M. C. 2017. *Characterizing the Fate and Mobility of Phosphorus in Utah Lake Sediments*. M. S. thesis. Department of Geological Sciences. Brigham Young University.

Spears, B. M., L. Carvalho, R. Perkins, A. Kirika, and D. M. Paterson. 2007. Sediment Phosphorus Cycling in a Large Shallow Lake: Spatio-Temporal Variation in Phosphorus Pools and Release. *Hydrobiologia* 584(1): 37–48. https://doi.org/10.1007/s10750-007-0610-0.

4 Project Tasks

DWQ is seeking a qualified entity to provide technical support to the ULWQS Science Panel to assist with collecting information on Utah Lake sediment–water nutrient interactions. The tasks within this scope of work reflect a recommended approach for this work and are designed to help the proposer

meet the study objectives and expected outputs and outcomes, which support the Science Panel in accomplishing its duties and fulfilling the Steering Committee's Charge (Attachment B). Proposers should feel free to include additional tasks in the proposals as they see appropriate to best achieve the study objectives and expected outcomes.

The deliverables for tasks presented in this Scope of Work will be reviewed collaboratively with the DWQ and ULWQS Science Panel. The selected contractor will work closely with the Science Panel to perform each task and is expected to be responsive to input and guidance provided by the Panel. If, during the course of the project, there are deviations from the project tasks as described here, the selected contractor should contact the Science Panel and come up with a mutually agreed upon course of action.

Task 1. Develop sampling and analysis plan (SAP)

A sampling and analysis plan (SAP) will be developed in accordance with the Utah DWQ's *Quality Assurance Program Plan for Environmental Data Operations, Final Plan* (Revision No. 1.0, see Attachment D). The essential elements for SAPs are listed in Appendix A of the *Quality Assurance Program Plan* and are as follows:

1. Introduction and background information
2. Objectives and design of the investigation
3. Special precautions and safety plan
4. Field sampling methods and documentation
5. Laboratory sample handling procedures
6. Analytical methods and laboratory documentation
7. Project quality control requirements
8. Data analysis, record keeping, and reporting requirements
9. Schedule and budget
10. Project team and responsibilities

Expected Deliverables

- Draft and final sampling and analysis plans in accordance with the Utah DWQ's Quality Assurance Program Plan for Environmental Data Operations, Final Plan.

Proposal Elements

Responses should:

- Provide demonstrated experience with developing sampling and analysis plans.
- Discuss a proposed approach for developing the deliverable for this task.

Task 2. Collect sediment cores from Utah Lake

Collect 78 cores with overlying water from two sites: a site in Provo Bay and a site in the main body of Utah Lake at an established DWQ monitoring site. Minimum core length is 20 cm. Cores will likely be collected by gravity corer or Jenkin surface sediment sampler by boat, or by SCUBA diving. Cores should be preserved in the dark and on ice for transport to the laboratory.

Expected Deliverables

- Electronic files with field observations

Proposal Elements

Responses should:

- Provide demonstrated experience with collecting sediment cores in shallow lakes for purposes of achieving the objectives described above.
- Discuss a proposed approach for developing the deliverable for this task.

Task 3. Perform sediment core experiments and laboratory analysis

Three experiments will be performed in the laboratory under dark conditions, following the general approach used in Spears et al. (2007). The experiments will be performed on cores collected from two sites in Utah Lake—one site in Provo Bay and one site from the main body of the lake at an established DWQ monitoring site.

1. Aerobic conditions: Collect 12 cores per site, and apply the following laboratory treatments, with three replicates of each:
    a. Control: ambient P concentration
    b. 0.5 x ambient P concentration (dilute with reconstituted Utah Lake water)
    c. 2 x ambient P concentration
    d. 4 x ambient P concentration

    To generate turbulence and maintain suspended sediment throughout the experiment (~50 NTU), use a shaker table or an airstone and pump placed immediately above the unconsolidated sediment. Proposers may suggest alternative approaches to generate turbulence. Remove water samples from the bottom water at the beginning and end of ~72-hour incubation and analyze for soluble reactive phosphorus (SRP) and calcite. The proposer may suggest additional analytes (e.g., NH4-N or NOx-N); if additional analytes are proposed, the justification should be included in the proposal. Calculate change in SRP in overlying water and plot change in SRP vs. overlying water SRP concentration. Estimate equilibrium P concentration using linear regression.
2. Anaerobic conditions: Using the cores from experiment #1 after it has been completed, generate anaerobic conditions and estimate equilibrium P concentration for the same treatments as in experiment #1. Additional cores do not need to be collected for this experiment.
3. pH gradient: Generate turbulence in the same way as in experiment #1, and estimate equilibrium P concentration for two additional pH conditions.

In addition to the above three experiments, SOD will be measured in triplicate using sediment cores or *in-situ* at each site.

Table 1 summarizes the number of cores per experiment and identifies the cores that can be used for multiple experiments. 39 cores are needed for each of the two sites, for a total of 78 cores.

Table 1. Sediment core specifications

Experiment # (see above list)	Number of Cores	Dissolved Oxygen	Phosphorus Concentration	pH
1, 2, 3	3	Aerobic, then anaerobic	Ambient	Ambient (~8.5)
1, 2, 3	3	Aerobic, then anaerobic	0.5x	Ambient (~8.5)
1, 2, 3	3	Aerobic, then anaerobic	2x	Ambient (~8.5)
1, 2, 3	3	Aerobic, then anaerobic	4x	Ambient (~8.5)
3	3	Aerobic	Ambient	7.0
3	3	Aerobic	Ambient	9.5
3	3	Aerobic	0.5x	7.0
3	3	Aerobic	0.5x	9.5
3	3	Aerobic	2x	7.0
3	3	Aerobic	2x	9.5
3	3	Aerobic	4x	7.0
3	3	Aerobic	4x	9.5
SOD	3	–	–	–
Total # cores per site	*39*			

Expected Deliverables

- Electronic files with observations and laboratory results

Proposal Elements

Responses should:

- Provide demonstrated experience with performing sediment core experiments to calculate equilibrium phosphorus concentrations.
- Discuss a proposed approach for performing the sediment core experiments and laboratory analyses.

Task 4. Prepare technical report

Methods, results, and discussion that answers the study objectives. The technical report will include calculations and results of sediment equilibrium phosphorus concentrations under aerobic conditions, anaerobic conditions, and a pH gradient. It will also include estimates of sediment oxygen demand.

Expected Deliverables

- Draft and final technical reports

Proposal Elements

Responses should:

- Provide demonstrated experience with developing technical reports of this nature.
- Discuss a proposed approach for drawing conclusions from the experiments and developing the technical report for this task.

5 Key Personnel

Grant proposals should discuss in detail the team members proposed for each task, their directly related experience and expertise, and the allocation of effort among team members. Responses must detail the allocation of proposed hours for each task and team member in the table below. Please also include team members and time allocation for project management, project support such as technical editing and GIS, and other allocations not directly associated with the tasks and deliverables presented in this scope.

Task #	Deliverable	Team Member (hours)	Team Member (hours)	Team Member (hours)	Team Member (hours)
1	Deliverable 1				
	Deliverable 2				

6 Deliverables and Preliminary Due Dates

Deliverable due dates are based upon days from the contract award date. The project and all deliverables must be completed with consideration of the milestones in the table below, the scope of work response, and the final work plan after scope award. Any change in the execution date of the contract must result in a mutually agreed upon change in deliverable dates. All final products generated by the contractor will be transmitted to UDWQ in a mutually agreed upon format prior to the expiration of the contract.

Task	Deliverable	Due Date
Task 1 – Develop Sampling and Analysis Plan	Draft sampling and analysis plan (SAP) Final SAP	14 days after scope award 30 days after scope award
Task 2 – Collect Sediment Cores	Electronic files with field observations	80 days after scope award
Task 3 – Perform Sediment Core Experiments and Laboratory Analysis	Electronic files with observations and laboratory results	110 days after scope award
Task 4–Prepare Technical Report	Draft technical report Final technical report	150 days after scope award 170 days after scope award

7 Science Panel Collaboration and Data Sharing

Grant recipients are required to complete this scope of work in collaboration with the ULWQS Science Panel. Grant recipients will:

- Develop the final research work plan in consultation with the Science Panel;
- Be responsive to Science Panel input on the final approach, work plan, work plan execution deliverables, results, analysis, final report, and any other interest to the Science Panel;
- Make all data and information collected by this grant, or funded by the ULWQS, available to the Science Panel within 45 days of field or laboratory analysis.;

8 Evaluation and Award

Offers will be evaluated based on the following criteria listed in relative order of importance:

Selection Criteria	Weight
Key Personnel proposed for project work (experience, expertise, and reliability) and experience of specific team members proposed for discrete tasks	20%
Method of approach and proposer's ability to perform the requirements of the grant	20%
Demonstrated understanding of work elements in the context of existing products, the Utah Lake ecosystem, and the Science Panel Initial Charge	20%
Proposed approach for Science Panel collaboration and data sharing	20%
Price	20%

9 Cost Proposal Form

Offers must include a cost proposal utilizing the format provided below. Please ensure the cost proposal can be removed from the proposal for independent evaluation by including it as an attachment to the proposal or as a separate section at the end of the proposal. Note that indirect costs may not exceed 10% on contracts with other state and local governmental agencies, including colleges and universities.

Task #	Deliverable	Proposed Cost (USD)
Total		

10 Instructions for Grant Proposal Preparation

Proposals must include the following elements to qualify:

1) Proposals must follow the proposal template presented in Section 11
2) Proposals must:
    a. Include a discussion of successfully completed projects relevant to the specific deliverables in this scope of work;
    b. Demonstrate that proposed team members have direct experience with and are qualified for conducting the specific tasks and deliverables for which they are proposed. Team member qualifications and resumes must be included as an appendix to the proposal. Resumes will not be counted against the proposal page limit;
    c. Specify all project roles for the proposed team members including, but not limited to, project management, analytical tasks, GIS, technical editing, and any other proposed roles;
3) Proposed approach for how each task will be performed to achieve the purpose and deliverables outlined in this Scope of Work. Applicants may propose supplemental work elements necessary to achieve the expected outputs and outcomes;
4) Schedule for key milestones and deliverables;
5) A table of estimated level of effort for each team member by task utilizing the provided template (in Section5); and
6) A stand-alone cost proposal table utilizing the provided template (Section 9) to include key personnel rates, hours and rates for completing specific tasks and deliverables, total proposed hours, indirect costs, overhead, and total cost.

11 Proposal Template

1. Experience and Expertise
   1.1. Related project experience
   1.2. Experience and expertise of key personnel
2. Proposed Approach
   2.1. Task 1 (repeat for each task)
      2.1.1. Key team members
      2.1.2. Approach discussion
         2.1.2.1. Approach for required Scope of Work deliverables
         2.1.2.2. Supplemental approach
         2.1.2.3. Task milestones and deliverables
3. Approach for Science Panel Collaboration and Data Sharing
4. Project milestones and deliverables
   4.1. A table of project milestones and deliverables
5. Level of effort
   5.1. A table with level of effort estimates
6. Cost Proposal
   6.1. A stand alone cost proposal table
7. Resumes (not counted toward page limit)
8. Related Case Study (not counted toward page limit)

12 Notice to Proceed

Notice to proceed will be provided by DWQ after receiving a signed grant agreement and Science Panel approval on the final work.